Appln. No. 09/465,396
Amdt dated Nov 8, 2005
Reply to office action dated 07/08/2005

Listing of claims

Amendments to Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

Claims 1 to 42 are cancelled.

43.(currently amended) An apparatus as claimed in claim ~~69~~80, wherein said diffracting structure is located within a space confined by said microphones of said microphone array.

44.(canceled)

45.(canceled)

46.(canceled)

47.(canceled)

48.(currently amended) An apparatus ~~method~~ as claimed in claim 43, wherein the impedance boundary condition for said diffracting structure is given by the equation

$$\left[\frac{\partial p}{\partial n} + ik\beta p\right]_S = 0$$

wherein n is the outward unit normal and β is the normalized specific admittance.

49.(canceled)

50.(currently amended) An apparatus as claimed in claim ~~69~~80, wherein said processor creates steerable beam directions for said array ~~are created~~ by combining signals from each of said microphones based on solutions to an acoustic wave equation evaluated at each microphone position.

51.(currently amended) An apparatus ~~method~~ as claimed in claim 50, wherein said processor combines said signals ~~are combined~~ with time delays that depend on the solutions to said acoustic wave equation evaluated at the respective microphone positions.

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52.(currently amended) An apparatus ~~method~~ as claimed in claim 51, wherein ~~the~~ said processor weights signals from different microphones ~~are weighted~~ by optimizing the expression

$$E\{G(\omega)\} = \frac{e^{-\sigma_p^2}(W_0{}^H R_{ss}(\omega) W_0) + \left(1 - e^{-\sigma_p^2} + \sigma_m^2\right)(W_0{}^H \mathrm{diag}(R_{ss}(\omega)) W_0)}{e^{-\sigma_p^2}(W_0{}^H R_{nn}(\omega) W_0) + \left(1 - e^{-\sigma_p^2} + \sigma_m^2\right)(W_0{}^H \mathrm{diag}(R_{nn}(\omega)) W_0)}$$

where

$E(G(w))$ is the expected gain,

$\sigma_m{}^2$ is the variance of the magnitude fluctuations due to microphone tolerance,

$\sigma_p{}^2$ is the variance of the phase fluctuations due to microphone tolerance,

R_{ss} is a signal correlation matrix,

R_{nn} is a noise correlation matrix,

W_0, is a nominal value vector of weights assigned to each microphone in the array.

53.(currently amended) An apparatus ~~method~~ as claimed in claim 52, wherein said signal correlation matrix R_{ss} is derived from the equation

$$R_{ss}(\omega) = E\{S \bullet S^H\}/\sigma^2$$

and said noise correlation matrix is derived from the equation

$$R_{nn}(\omega) = E\{N \bullet N^H\}/\sigma^2$$

54.(currently amended) An apparatus ~~method~~ as claimed in claim 52, wherein said expression is optimized by maximization.

55.(canceled)

56.(canceled)

57.(canceled)

58.(canceled)

59.(canceled)

60.(canceled)

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61.(previously presented) An apparatus as claimed in claim 73, wherein said diffracting structure is in the form of a body with upwardly and outwardly sloping side walls, and said microphones are located at said side walls so that sound waves propagating across said array must travel around said body, or outwardly and over the top of said body.

62.(currently amended) An apparatus as claimed in claim ~~61~~80, wherein said body is in the form of an inverted cone or frusto-cone.

63.(canceled)

64.(canceled)

65.(canceled)

66.(canceled)

67.(currently amended) An apparatus method as claimed in claim ~~64~~ 51, wherein the time delays are set according to the equation

$$\omega\tau_m = -\arg[F(\mathbf{r}_m, \mathbf{r}_l)]$$

68.(currently amended) An apparatus ~~method~~ as claimed in claim ~~63~~80, wherein said diffracting structure is a sphere and sound field is determined in accordance with the equation

$$F(\mathbf{r}, \mathbf{r}_o) = iC\sum_{n=0}^{\infty}(2n+1)P_n(\cos\psi)\, h_n^{(1)}(kr_>)\,[\, j_n(kr_<) - a_n h_n^{(1)}(kr_<)]$$

where ψ is the angle between vectors $\boldsymbol{r}$ and r_o, P_n is the Legendre polynomial of order n, j_n is the spherical Bessel function of the first kind and order n, $h_n^{(1)}$ is the spherical Hankel function of the first kind and order n, $r_< = \min(r, r_0)$, n, $r_> = \max(r, r_0)$, and

$$a_n = j_n'(ka)/h_n^{(1)\prime}(ka)$$

69.(canceled)

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70.(currently amended) An apparatus as claimed in claim ~~69~~80, wherein said diffracting structure is constructed so that surface waves can form over its surface and thereby modify the travel time of sound waves across said array.

71.(currently amended) An apparatus as claimed in claim ~~69~~80, wherein said processor combines said signals with a time delay that takes into account the propagation times across said array and the effects of said diffracting structure.

72.(previously presented) An apparatus as claimed in claim 71, wherein said processor is programmed to sum said signals to form a steerable beam.

73.(previously presented) An apparatus as claimed in claim 72, wherein said processor is programmed to weight said signals prior to summing them.

74.(previously presented) An apparatus as claimed in claim 72, wherein the time delays are set according to the equation

$$\omega\tau_m = -\arg[F(\mathbf{r}_m, \mathbf{r}_l)]$$

75.(previously presented) An apparatus as claimed in claim 74, wherein said diffracting structure is a sphere and said sound field is determined in accordance with the equation

$$F(\mathbf{r}, \mathbf{r}_o) = iC \sum_{n=0}^{\infty} (2n+1) P_n(\cos\psi)\, h_n^{(1)}(kr_>)\,[\,j_n(kr_<) - a_n h_n^{(1)}(kr_<)]$$

where ψ is the angle between vectors $\boldsymbol{r}$ and r_o, P_n is the Legendre polynomial of order n, j_n is the spherical Bessel function of the first kind and order n, $h_n^{(1)}$ is the spherical Hankel function of the first kind and order n, $r_< = \min(r, r_0)$, n, $r_. = \max(r, r_0)$, and

$$a_n = j_n'(ka) / h_n^{(1)\prime}(ka)$$

76.(canceled)

77.(currently amended) An apparatus as claimed in claim ~~76~~80, wherein the surface of said diffracting structure is provided with surface damping.

78.(currently amended) An apparatus as claimed in claim ~~76~~80, wherein the surface

impedance of said diffracting structure has a spring-like reactance to enhance the propagation of surface waves.

79.(canceled)

80.(currently amended) ~~An~~ A microphone apparatus with passive beam steering, comprising:

a microphone;

a diffracting structure proximate said array to modify the acoustic properties thereof, said microphone array and diffracting structure being associated with a characteristic sound field describing said acoustic properties; and

a processor programmed to process weighted signals from individual microphones in said microphone array to create a steerable beam based on the location of said individual microphones and the predetermined properties of said sound field taking into account the modifying effect of said diffracting structure;

wherein the surface of said diffracting structure is configured to modify the acoustic impedance thereof;

wherein the surface of said diffracting structure includes an open-cellular structure; and

~~as claimed in claim 79,~~ wherein the lateral size of the cells forming said cellular structure is a fraction of the wavelength of the sound.

81.(previously presented) An apparatus as claimed in claim 80, wherein the microphones are located in said cells away from pressure nodal points.

82.(canceled)

83.(canceled)

84.(canceled)

85. (currently amended) A microphone apparatus as claimed in claim ~~69~~80, wherein signals from said microphones are processed using the following method:

(aa) determining an expression for an expected gain of said array, said expression being dependent on weights assigned to each signal from a microphone in the array,

(ab) determining the optimum microphone weights that maximize said expression,

(ac) applying weights to said microphone signals, and

(ad) summing the weighted microphone signals,

wherein said expression also contains variables representing a variance of magnitude fluctuations from inputs from said microphone and a variance of phase fluctuations from said inputs from said microphone.

86.(withdrawn) A microphone apparatus as claimed in claim 85 wherein said expression is

$$E\{G(\omega)\} = \frac{e^{-\sigma_p^2}(\mathbf{W_0}^H\mathbf{R}_{ss}(\omega)\mathbf{W}_0)+\left(1-e^{-\sigma_p^2}+\sigma_m^2\right)(\mathbf{W_0}^H\mathrm{diag}(\mathbf{R}_{ss}(\omega))\mathbf{W}_0)}{e^{-\sigma_p^2}(\mathbf{W_0}^H\mathbf{R}_{nn}(\omega)\mathbf{W}_0)+\left(1-e^{-\sigma_p^2}+\sigma_m^2\right)(\mathbf{W_0}^H\mathrm{diag}(\mathbf{R}_{nn}(\omega))\mathbf{W}_0)}$$

where

$E(G(w))$ is the expected gain,

σ_m^2 is the variance of the magnitude fluctuations due to microphone tolerance,

σ_p^2 is the variance of the phase fluctuations due to microphone tolerance,

R_{ss} is a signal correlation matrix,

R_{nn} is a noise correlation matrix,

W_0, is a nominal value vector of weights assigned to each microphone in the array.

87. (withdrawn) A microphone apparatus as claimed in claim 86 wherein step (ad) is accomplished by setting the vector W_0 equal to the eigenvector which corresponds to the maximum eigenvalue of the symmetric matrix

$$A^{-1}B$$

where

$$A = \left(e^{-\sigma_p^2}\mathbf{R}_{nn}(\omega)+\left(1-e^{-\sigma_p^2}+\sigma_m^2\right)\mathrm{diag}(\mathbf{R}_{nn}(\omega))\right)$$

$$B = \left(e^{-\sigma_p^2}\mathbf{R}_{ss}(\omega)+\left(1-e^{-\sigma_p^2}+\sigma_m^2\right)\mathrm{diag}(\mathbf{R}_{ss}(\omega))\right)$$

88.(canceled)

89.(canceled)

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90.(withdrawn) An apparatus as claimed in claim 87, wherein said signal correlation matrix R_{ss} is derived from the equation

$$R_{ss}(\omega) = E\{S \bullet S^H\}/\sigma^2$$

and said noise correlation matrix is derived from the equation

$$R_{nn}(\omega) = E\{N \bullet N^H\}/\sigma^2$$